Operating Manual

LDS V450 Series Vibrators

Manual 3005370

Issue 3

Brüel & Kjær

BEYOND MEASURE

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Drawings included with this manual No.

Associated publication No.

LDS MANUALS

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LDS manuals are continually updated to suit different configurations and applications. For certain products and systems some information in this manual may not be relevant; where it does not apply it should be ignored.

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ISSUE HISTORY

Operating Manual, LDS V450 Series Vibrators

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Amendments

Date	*Issue*	*Sections Affected*	*Brief Details*	*ECO*
12.9.17	1	All	Replaces Manual 896291 for LPA amplifiers	EP0231
24.1.18	2	All, Figure 1	Warning notices, schematic	–
5.4.18	3	Figure 1, 3.3, 6.3	Fan fuse and interlock	VTS10101

HEALTH AND SAFETY NOTICES

DEFINITIONS

For the purposes of this manual:

Danger Zone means a zone extending 2 m (6 ft) from the periphery of the vibrator and cabling.

Note: Outside this zone noise may still be a risk to health and safety.

Exposed Person means any person either wholly or partially in the danger zone.

Operator means any person transporting, installing, adjusting, operating, cleaning, maintaining or repairing the vibration system.

Main Control Position is next to the vibration control unit.

Payload means the test piece, part or assembly under test including any jigs, fixtures, accelerometers and fastenings used to mount it to the vibrator moving element.

SELV means Safe Extra Low Voltage

RISKS & HAZARDS

When planning, installing, operating or maintaining a vibration test system, careful consideration must be given to the potential hazards inherent in the use of such equipment. The information contained in these notices and elsewhere in Brüel & Kjaer technical publications should be considered as part of provision and use of work equipment (PUWER or equivalent) assessments. Where risks and hazards are identified, appropriate warning signs should be displayed and exclusion zones defined.

Noise

Exposure of the human body to high noise levels can damage health. Electrodynamic vibration test equipment can generate significant noise levels and ideally should be sited within a soundproof cell. The operator control position, together with signal generation, control and monitoring equipment should be located outside the soundproof cell. Power amplifiers, cooling units and other ancillary equipment can also generate significant noise levels and should be located away from the operator control position. If the ideal situation is impractical, all personnel at risk must be made aware of the hazards involved and a directive issued that ear defenders should be worn.

Mechanical

It must be remembered that vibrators can be used to test equipment to destruction and that the forces available can be considerably amplified by local resonances. Precautions must be taken to ensure that any parts of the payload which may become detached cannot cause injury to personnel.

Payloads must be designed and mounted such that they cannot overturn the vibrator either statically or under test. Further, they must not exceed the rated load of the vibrator bearings.

In so far as their purpose allows, payloads should have no sharp edges, no sharp angles and no rough surfaces likely to cause injury. Payloads should also have no trapping points e.g. where fingers or hands might be trapped during test.

It is recommended that all persons entering the danger zone, whether the vibrator is energised or not, are aware of the risks and that appropriate protective clothing is worn. Other risks specific to siting and operation of the vibrator are identified in the relevant sections of this manual.

Electrical

All equipment constituting a vibration test system contains voltages above SELV and is potentially lethal. During normal operation it is not necessary for an operator to access areas containing voltages above SELV. Access to high voltage areas can only be gained by removing panels or covers, or by opening doors with the use of a tool (including a key).

It is the policy of Brüel & Kjaer to supply two keys for each lock position. To ensure that access to the interior of equipment is restricted to designated personnel, it is strongly recommended that all keys are held by a responsible person, authorised to issue keys for service/maintenance purposes.

With the exception of calibration or fault diagnosis by qualified personnel, equipment should be completely isolated from the supply before gaining access. Residual hazardous voltages may be present immediately after isolation.

Pneumatic

Some vibrators rely on a compressed air supply for armature and body support. Due care and attention must be given when fixing loads to the armature and subsequently setting armature and body positions.

It is recommended that the air supply has a shut-off valve adjacent to the vibrator for use in emergencies or when the vibration system is not being used e.g. overnight. In such cases the payload should be supported by other means e.g. armature lock-out plates or overhead crane.

Hydraulic

Some vibrators and all combos use Shell Tellus oil or equivalent. Whilst this oil does not pose a direct health and safety hazard, care should be taken to clean up any spillages which may occur during filling, draining or operating the system. It is also recommended that any oil making skin contact is removed as soon as possible.

Water

Some vibrators are water-cooled with the cooling system self-contained within the vibrator, hoses and cooling unit. Although water can only be released (leak) due to a failure in the system, operators should be made aware of the temperatures attained during normal operation (see below).

Temperature

The heat generated by all equipment in the vibration test system should be considered before siting. Measures should be taken to ensure that the temperature of the working environment for the system and operating personnel is within allowable limits. Operators should also be made aware that some equipment, particularly water cooled vibrators, can attain high surface temperature during normal operation.

Blower Outlet (Air-cooled vibrators)

The air outlet port from the cooling blower in air-cooled vibrator systems should be positioned such that an operator cannot stand directly in line with the airflow. This precaution will prevent injury in the event of small objects, e.g. nuts or screws becoming detached in the vibrator and ejected at high velocity from the blower.

Cables and Hoses

Where practical, all cables and hoses used in the vibration test system should be sited in ducts or trunking to give clear unimpeded access to the vibrator, power amplifier, cooling unit and other ancillary equipment.

Chemicals

The hazards of chemicals/cleaning agents are dependent not only upon the toxicity of materials but also upon the degree and nature of exposure. Users should adopt procedures conforming to the requirements of the European Directive 90/394/EEC, Protection Of Workers From The Risks Related To Exposure To Carcinogenic Substances At Work, which is implemented in the UK by the COSHH regulations.

IMPORTANT NOTE: In special cases where vibrator rolling seals are required to have resistance to fuel oil, the standard white SILICON vibrator seal may be replaced by a black VITON seal. In the event of a fire, anyone handling residues of VITON must wear Neoprene protective gloves to avoid skin contact with possibly highly corrosive residues which are likely to include hydrogen fluoride. DISCARD GLOVES AFTER USE.

Magnetic Fields

Electromagnetic vibrators and associated power products produce DC and low-frequency magnetic fields. In the light of medical research on the effect of electromagnetic fields on the human body, Brüel & Kjaer recommend that wearers of electromedical implants take especial care not to enter the danger zone while the vibrator is operational.

Brüel & Kjaer cannot accept responsibility for any effects on health of electromagnetic fields but strongly advise that all precautions as defined in this notice and product manuals are followed.

INSTALLATION

Line of Sight

From the main control position it must be possible to ensure that there are no exposed persons in the danger zone. For vibration systems in which there is no direct line of sight or video link between the control position and the vibrator, it is recommended that an audible warning device is fitted at the vibrator location to give notice of impending operation. This will give personnel in the danger zone opportunity to vacate the area, or actuate the emergency stop to prevent vibrator operation.

Emergency Stop

For most vibration test systems, the vibrator is fitted with a minimum of one locking emergency stop pushbutton, and includes the facility for additional emergency stop pushbuttons at other locations. It is recommended that on large systems (with the vibrator in the horizontal mode) or with combos, the additional emergency stop(s) are located adjacent to the payload position, in easy reach of an operator working in that area.

Additional emergency stop switches must comply with BS EN418-1992

OPERATION

LDS systems are designed to provide a controlled vibration testing environment for quality and reliability testing of components and assemblies, within the limits stated in the specifications. Any other use, e.g. in an explosive or corrosive environment, unusual loading, etc, may invalidate contractual agreements. Any doubts regarding the fitness for purpose of the equipment should be referred to Brüel & Kjaer Technical Department before the equipment is used.

Chapter 2 Technical Data

2.1 Specification

Sine force, peak (Note 1)	
fan cooling	V450: 311 N (70 lbf) V455: 489 N (110 lbf)
natural cooling	V450/V455: 177 N (40 lbf)
Random force rms, fan cooling (Note 2)	V450: 214 N (48 lbf) V455: 294 N (66 lbf)
Velocity, sine peak (Note 1)	V450: 1.78 m/s (70.1 in/s) V455: 2.5 m/s (98.4 in/s)
Acceleration, sine peak (Note 1)	V450: 730 m/s² (74.4 g_n) V455 : 1147 m/s² (117 g_n)
Armature resonance (f_n), nominal	6000 Hz
Useable frequency range	dc to 7500 Hz
Stray magnetic field	
50 mm above table	2 mT
100 mm above table	0.75 mT
Maximum armature current	
fan cooling	V450: 11 A, V455: 13 A
natural cooling	7 A
Armature diameter	63.5 mm (2.5 in)
Armature suspension stiffness, axial	17.5 kN/m (100 lbf/in)
Displacement, pk-pk	19 mm (0.75 in)
Effective mass of moving element	0.426 kg (0.94 lb)
Mass/spring resonance, nominal	32 Hz

Notes

1. Force, velocity and acceleration ratings depend on the amplifier driving the vibrator; the values stated assume the LDS LPA600 amplifier for the V450 and LPA1000 for the V455.
2. Random rating assumes a payload approximately twice the mass of the armature. For advice on specific test requirements, contact Brüel & Kjaer.

2.2 Offset loads

The following values for the V450 vibrator should be used in the offset load formula described in the appendix:

Maximum turning moment of armature guidance system ('A')	3.0 N m
Distance from defined null point to armature mounting face ('B')	0.045 m

2.3 Environmental

Maximum heat rejected to air	
via body	V450: 0.03 kW, V455: 0.08 kW
via cooling fan	V450: 0.30 kW, V455: 0.74 kW
Working ambient temperature	0° to +30° C (+32° to +86° F)
Working ambient pressure	900 to 1100 mbar (27 to 33 in Hg)
Relative humidity (non-condensing)	0% to 90%
Airflow inlet temperature range	0° to +30° C (+32° to +86° F)
Airflow through cooling fan	0.01 m³/s (25 ft³/min)
Maximum acoustic noise (see Note 2)	Vibrator 105 dBA, fan 62 dBA

<table>
<tr><th>Weights and dimensions (see Note 3)</th><th>Base-mounted</th><th>Trunnion-mounted</th><th>Fan</th></tr>
<tr><td>Weight</td><td>64 kg (141 lb)</td><td>81.7 kg (180 lb)</td><td>15 kg (33 lb)</td></tr>
<tr><td>Height</td><td>290 mm (11.4 in)</td><td>395 mm (15.6 in)</td><td>249 mm (9.8 in)</td></tr>
<tr><td>Width</td><td rowspan="2">265 mm (10.4 in)</td><td>375 mm (14.8 in)</td><td>241 mm (9.5 in)</td></tr>
<tr><td>Depth</td><td>275 mm (10.8 in)</td><td>186 mm (7.3 in)</td></tr>
</table>

Notes

1. The customer is responsible for: mains supply and fuses, all trunking or conduit, air conditioning, ventilation and soundproofing. Customer responsibilities are shown in dotted detail on interconnection diagrams.
2. The determination of noise levels is a varied and complex procedure. Figure 2 shows the conditions under which the values in the tables were obtained.
3. Dimensions/weight may vary according to options fitted.

Chapter 1 Introduction

The V450 Series electro-dynamic vibrator is a wide frequency band transducer suitable for use in applications such as

- modal and structural analysis
- electronic assembly testing
- laboratory experiments
- fatigue and resonance testing
- use as a velocity transducer or high-speed actuator

To allow maximum performance to be obtained, provision is made for the vibrator to be force cooled; an external fan for this purpose is available from Brüel & Kjær.

The vibrator can be supplied trunnion-mounted, allowing rotation up to 90° either side of the vertical.

An armature overtravel switch is connected to an amplifier interlock; an additional system interlock can be fitted as described in the amplifier manual

The vibrator is supplied in four combinations of armature impedance and payload attachment fittings:

- V450 – low-impedance, metric fittings
- V451 – low-impedance, imperial fittings
- V455 – high-impedance, metric fittings
- V456 – hight-impedance, imperial fittings

While the vibrator can be driven by any suitable amplifier, this manual assumes the following LDS amplifiers as shown in Figure 1:

- LPA600 with V450 and V451
- LPA1000 with V455 and V456

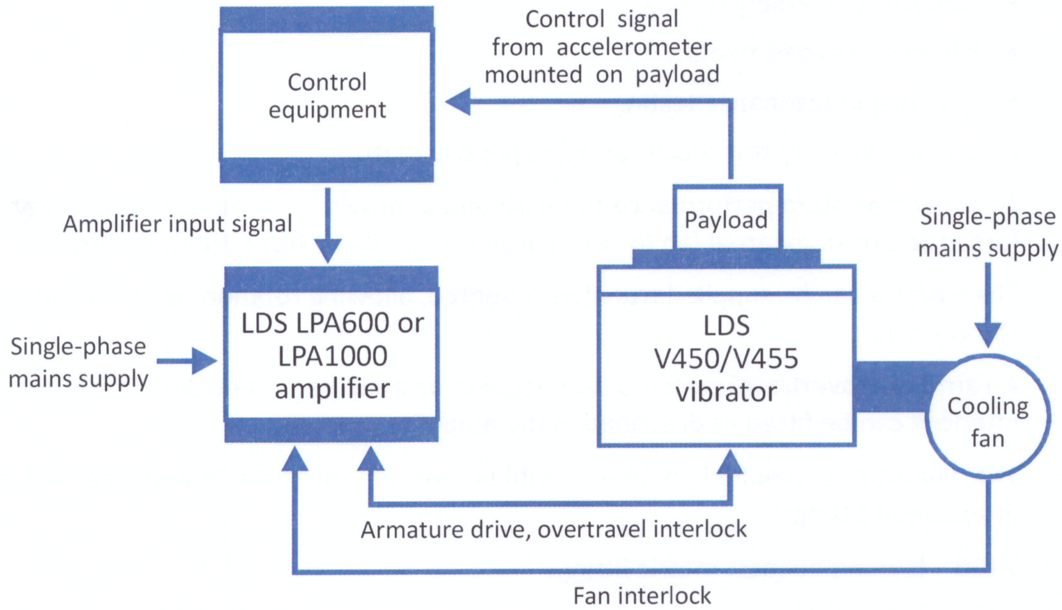


Figure 1 ***V450 vibration test system with LPA amplifier***

(3)

Before-use Checks

Before operating any vibration system, check that:

- the vibration test area is clear of unnecessary obstructions.
- all terminal covers are correctly fitted.
- all equipment doors are correctly closed and secure.
- the supply of cooling medium (if applicable) is sufficient.
- the hydraulic oil supply (if applicable) is correctly topped-up.
- the item under test is correctly secured to the vibrator or slip table.
- all personnel are clear of the danger zone

Emergency Stop

If an emergency arises, the emergency stop should be activated immediately.

Remote Control Operation

For systems including a remote control panel (RCP), operation is only permitted from one control position (amplifier or RCP). This protection is provided either by software selection or by keyswitch operation, the key being common for both positions. Although Brüel & Kjaer provide more than one key, it is strongly recommended that only one is issued and its use restricted to the authorised operator. This will provide added protection against system mal-operation or misuse.

TRAINING

Vibration test systems encompass a wide variety of technological disciplines and it is essential that personnel are properly qualified and trained before being authorized to work on such a system. Access to areas where vibration test systems are located should be restricted to authorised personnel. Brüel & Kjaer offers short training courses providing a practical introduction for technicians/engineers new to vibration testing.

MAINTENANCE

A programme of planned maintenance, carried out by fully trained and qualified personnel, is essential to maintain the safety of the equipment. Safety interlocks must be frequently checked for correct operation. Under no circumstances should protective earth conductors be left disconnected; these should be frequently checked to ensure good earth bonding of all equipment. Frequent checks on armature and field coil insulation should be carried out in accordance with the detailed vibrator maintenance section of this manual.

CUSTOMER RESPONSIBILITIES

When specifying, siting, installing and operating a vibration system the customer is responsible for the following:

1. Off-loading, unpacking and siting the equipment at its designated position.
2. Ensuring that the floor surface where the equipment is to be located is suitable for the equipment.
3. Ensuring that access to the equipment is adequate.
4. Providing all service requirements such as water, air lines, electrical power etc. to the point of entry to the equipment and ensuring that such supplies conform to company specifications.
5. Supplying all test equipment necessary to complete acceptance testing.
6. Making available consumable materials such as distilled water, oil, cleaning material etc.
7. Any special tools required for commissioning the system such as lifting equipment etc.
8. Completion of pre-installation check list prior to commencement of installation
9. To validate warranty, return to Brüel & Kjaer on completion of all installations or commissioning of the signed commissioning certificate.
10. PAYLOADS AND THEIR EFFECT ON THE VIBRATOR ARE THE RESPONSIBILITY OF THE CUSTOMER.

VISUAL SYMBOLS

The following visual symbols may be used on the equipment:

Symbol	Description
∼	Alternating current
⏚	Earth (ground) terminal
⊜	Protective conductor terminal
⚠ (lightning)	Caution - risk of electric shock
⚠	Caution - risk of danger

CONFORMITY

LDS equipment is designed specifically for vibration testing and should not be used for any other purpose except by agreement with Brüel & Kjaer.

The equipment complies where applicable with the following European Union (EU) directives:

Machinery	2006/42/EC
Low Voltage	2014/35/EU
EMC	2014/30/EU

For installation, use and maintenance of this equipment the responsibilities of employer and employee are specified in Work Equipment Directive 2009/104/EC which refers to suitability of work equipment, maintenance, specific risks, information & instructions and training. The directive is implemented in the United Kingdom by statutory regulations 'Provision and Use of Work Equipment Regulations 1998' and by similar regulations in other EU countries.

LDS product design provides personal protection in accordance with the applicable directives listed above, and care has been taken to minimise the risks associated with all equipment constituting a vibration test system. Since however the vibrator and other equipment contains moving parts and can exert large forces on jigs, fixtures and payloads, the area surrounding such equipment should be declared a Danger Zone (see Definitions) and suitable precautions taken by operators working there.

BRÜEL & KJAER DOES NOT ACCEPT RESPONSIBILITY FOR RISKS INTRODUCED BY JIGS, FIXTURES AND PAYLOADS.

FOR LDS JIGS AND FIXTURES SEE THE APPROPRIATE MANUAL.

LDS equipment as supplied by Brüel & Kjaer meets the essential requirements of all applicable EU directives. To maintain compliance the equipment must be maintained and serviced by personnel certified by Brüel & Kjaer as having successfully completed a Brüel & Kjaer approved training course relating to the equipment. Only parts and components supplied under a Brüel & Kjaer part number or otherwise specifically approved by Brüel & Kjaer shall be used in the maintenance and servicing of the equipment.

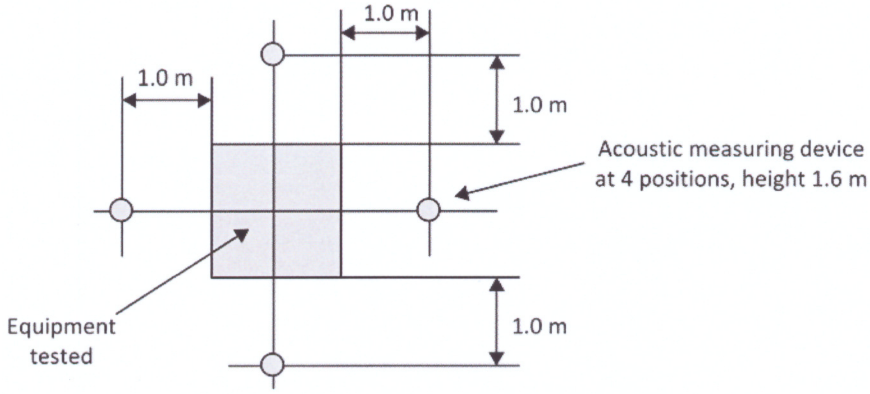


Figure 2 ***Noise measurement - plan view***

2.4 Labelling

The following textual labels are affixed to the vibrator:

a) **"**Use ear protectors; Warning – high temperature**"**

b) "Model no; serial no; date of manufacture"

Chapter 3 Description

3.1 Construction

The vibrator consists of a magnet housing which contains a permanent magnet, which generates a magnetic field in the annular gap surrounding the armature drive coil. The armature and drive coil assembly is suspended on two flexures; the flexures are attached to the vibrator body by support pillars. A top cover fitted with a dust seal prevents the ingress of potentially damaging abrasive material.

The armature assembly consists of a cylindrical copper coil bonded to a cast magnesium radial-finned structure. The armature is located around the top of the centre pole assembly and occupies part of the air gap in the magnetic structure. The armature flexures provide axial support as well as lateral and rotational restraint.

When current is applied to the armature coil conductors, which are at right angles to the magnetic flux in the air gap, a resulting force is produced which is mutually perpendicular to the air gap flux and direction of the armature current. An alternating current thus produces an alternating force.

Armature drive is applied to the vibrator via the input socket; a suitable cable is supplied with the LDS amplifier.

3.2 Mounting

The vibrator can be secured to the floor or other fixed surface either directly or by the optional trunnion base.

Base- and trunnion-mounting holes are shown on the outline drawing included with this manual.

3.3 Cooling option

The optional external fan can be used to remove heat from the vibrator. Ambient air enters the vibrator through the intakes situated on either side of the top cover and is exhausted by the fan.

If power to the fan motor is lost an amplifier interlock is triggered. (3)

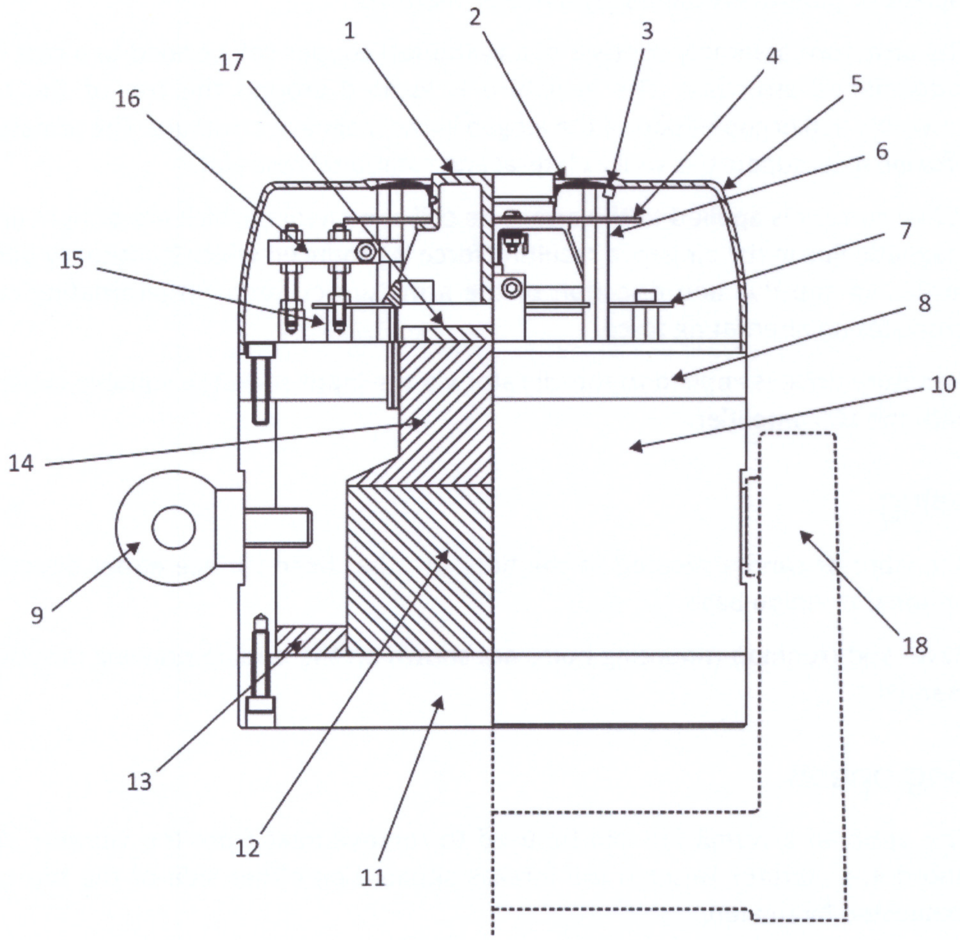
3.4 Electrical connection

Electrical connections to the vibrator are made through a five-pin input socket in the top cover as shown in the interconnection diagram included with this manual.

The vibrator earth connection is via the input socket.

3.5 Overtravel interlock

Armature overtravel protection is provided through normally-closed mechanically actuated contacts connecte to an amplifier interlock circuit. Should the armature exceed the rated stroke, the overtravel switch will make physical contact with a striker on the armature, open the interlock circuit and initiate amplifier shut down.



1. Armature
2. Dust seal
3. Bump stop
4. Upper flexure
5. Top cover
6. Support, upper suspension
7. Lower flexure
8. Top plate assembly
9. Lifting eyebolt (*when removed, holes blanked with grommets)*
10. Body assembly
11. Bottom plate
12. Magnet
13. Magnet locating resin
14. Centre pole
15. Support, lower suspension
16. Overtravel switch assembly
17. Bumper pad
18. Trunnion option

Figure 3 ***V450 vibrator***

Chapter 4 Installation

WARNING

- Incorrect lifting methods can cause serious personal injury and damage to the equipment.
- Attention is drawn to the safety precautions and hazard warnings contained within the preface to this manual.

4.1 General

Check the equipment received against the packing list. Inspect all equipment for transit damage, and advise Brüel & Kjaer of any problems within 48 hours.

All dimensions necessary for the installation of the vibrator are shown on the outline drawing included with this manual.

The vibrator should be installed in a location which is free of airborne ferromagnetic particles. Any operation that produces such by-products in the installation area should be performed only after adequate measures to protect the vibrator have been taken.

There are the following constraints on the siting of the vibrator:

- The length of power and signal cables are as given in the interconnection drawing included with this manual.
- The length of the air suction hose between the vibrator and the fan should not exceed 1.8 m (6 ft).

It is recommended that the vibrator be placed close to the control equipment to facilitate monitoring by the operator.

It is recommended that in a permanent installation, the vibrator base (or trunnion base when supplied) is secured to the surface on which the vibrator stands, to prevent vibration of the body.

Important Note: The holes in the vibrator body must be fitted with the grommets provided when the holes are not used for eyebolts or trunnion clamp screws (see Figure 3). If the grommets are not fitted the armature coil will overheat and rapidly fail.

4.2 Lifting

The base-mounted vibrator has two lifting eyebolts in the side of the body, which must be replaced by grommets after use (see also Chapter 3, 'Mounting').

The trunnion base has two attachment points for lifting eyebolts (see outline drawing).

To lift the vibrator, a crane of sufficient lifting capacity together with suitable lifting slings and spreader must be used. No attempt must be made to lift the vibrator other than by the eyebolt attachment points.

CAUTION

- Special lifting instructions for any particular configuration will be printed on the outer packaging. Where they exist they must be strictly adhered to.

Chapter 5 Operation

5.1 General

The V450 series vibrator, when part of a vibration test system, can handle relatively large amounts of power. Incorrect application of power can have a devastating effect on the vibrator and load-under-test.

WARNING

- This equipment should only be operated by persons trained in the techniques of vibration testing.

Operation of the vibrator is relatively simple but care must be taken to avoid overloading the vibrator electrically or mechanically and damaging the vibrator or amplifier.

5.2 Load attachment

The vibrator load mounting table is provided with six tapped holes for load attachment (see outline drawing included with this manual). The best dynamic performance will result if all the holes are used.

CAUTION

- Do not drill additional holes in the load mounting table. Drilling of additional holes will weaken the table and may result in damage to the equipment.

Recommended torque values for load attachment screws are as below.

Thread	Torque
M5 (V450/455)	9.0 Nm (6.7 lbf ft)
10-32"– UNF (V451/456)	7.3 Nm (5.4 lbf ft)

The table should be firmly gripped while the screws are tightened to prevent a rotating movement which could cause damage to the internal suspension.

Looseness or excessive compliance in any of the mechanical connections between the driving coil and the test load will cause erratic uncontrolled test levels and frequency components. Difficulties caused by such looseness can be detected with an oscilloscope connected to the accelerometer output.

Serious departure from a sinusoidal response, or more particularly, the addition of high frequency non-harmonic noise components superimposed on the waveform is nearly always an indication of decoupling between the armature and fixture; fixture and load; or looseness within the fixture.

Bolted connections within the fixture should always be avoided as much as possible, welded or casting is preferable.

Care must be exercised in locating the load over the armature table. The fixture height should be minimised to keep the centre of gravity as close to the table as possible. Driving a complicated fixture and load causes coupled modes of vibration which can only be reduced by vigorous symmetry and careful alignment of the load over the thrust axis of the armature.

Load attachment is a specialised problem which must be solved for each load. The motion of the table and fixture with the load in place may be checked with a series of measurements taken with lightweight crystal accelerometers.

Vertical operation

For vertical operation, the flexure support capabilities must be considered before attaching a load and fixture to the vibrator table. In order to obtain maximum stroke of the armature, the weight of the load and fixture must be supported by a low stiffness spring, such as rubber shock cords, such that the armature is returned to its original neutral position.

If less than the maximum armature stroke is required for the test, a static deflection of the armature is permissible subject to:

The sum of the required displacement (half-sine peak) and the static deflection being less half the maximum displacement i.e.

$\frac{M}{k} + d$ is less than 9.5 mm

where

M = Mass of payload plus armature (kg)

k = stiffness of suspension (kg/mm)

d = required displacement (mm 1/2 sine peak)

Horizontal operation

During horizontal operation the suspension flexures will centre the armature and payload axially. However, care must be taken to ensure that excessive load is not applied to the armature suspension by an overhanging load. This could result in scuffing of the armature coil in the air gap and rapid failure.

The overhanging payload mass must not exceed:

$\frac{300}{(45 + x)}$ kg

where x is the distance in mm between the payload centre of gravity and the payload mounting face.

For overhanging masses in excess of the above figure independent suspension of the payload is necessary.

5.3 Pre-operational checks

Observation of the waveform through the use of a suitable accelerometer and oscilloscope is the most sensitive test for proper vibrator operation. The following test is recommended:

1. Mount an accelerometer on the armature table. In the case of installations where the vibrator is earthed, the accelerometer should be insulated from the vibrator armature to prevent ground loops.
2. Connect the accelerometer output to an appropriate amplifying system with the accelerometer amplifier output connected to an oscilloscope.
3. With the accelerometer mounted and connected as described, scan the frequency range at several different levels noting waveform.

   It is necessary to be able to differentiate between normal and abnormal distortion. Serious departure from a sine wave is usually an indication of armature or suspension misalignment or damage. Some distortion at sub-mulitiples of the resonance frequency may be expected due to the amplification of a small percentage of the amplifier distortion.

   It is strongly recommended that a record should be made of the armature resonance frequency and harmonic wave form when the vibrator is received. A check with this record will enable trained personnel to differentiate between normal and abnormal distortion. A periodic check with this record will minimise trouble shooting time and is also a very good preventative maintenance check.

   Check the overtravel protection circuit to ensure proper operation of the switch and correct cable connections. The overtravel switch is pre-set at the factory.

5.4 Operating procedure

Care should be taken when operating the vibrator to avoid damage to the suspension or armature coil. Damage can be caused by transients in the supply waveform or by exceeding the displacement, acceleration, or force limits. Therefore, the following points should be borne in mind:

- If the vibrator is being controlled manually through the frequency range, this should be done slowly with a watch being kept on acceleration as the armature resonance frequency is approached.
- Avoid switching the oscillator to a different range without first reducing the amplifier output to zero, otherwise the resulting transient could exceed the acceleration limit.
- Care must be taken at the low frequency end to see that the maximum displacement is not exceeded, otherwise the armature will strike the mechanical stop with an impact which exceeds the acceleration limit.
- It is important that the maximum armature current and force for the vibrator and cooling condition are not exceeded, otherwise overheating will result. Refer to Chapter 2, 'Specification' for force and current limits.

Note: The velocity limit with any particular vibrator/amplifier configuration will depend entirely on available amplifier voltage.

Chapter 6 Maintenance

6.1 Maintenance policy

It is strongly recommended that a full maintenance contract is taken out with Brüel & Kjær, which provides for an annual comprehensive service of the equipment.

6.2 Operating log

The equipment history can prove invaluable should advice be required from Brüel & Kjær, so users are strongly advised to keep a daily log recording the following information:

- Number of hours run
- Timetable of system faults/interlock trips
- Cause of faults/interlock trips (if known)
- Action taken to rectify faults
- Any matters of concern.

6.3 Service and spares

Recommended spares holdings, tools and general service advice are available on request from Brüel & Kjær Service Dept.

User spares list

Part Number	Description	Quantity
705580	Fan hose clip	2
710870	Fan hose	1
2036730	Fan fuse FS1 T,5A,H,250V,5 x 20mm	1	(3)

Appendix – Offset load calculations

1. The offset load formula

An electrodynamic vibrator is designed to operate in a single axis. The moving part of the vibrator, the armature assembly, must be guided to maintain the armature coil in the centre of the magnetic air gap. The guidance system will have low stiffness along the vibration axis, and high stiffness at right angles to this axis (cross-axially).

Details of the guidance system for V450 vibrators are given in Chapter 3 'Description'.

Any guidance system will have limitations in the cross-axial direction. Excessive loading in this direction may cause the armature to rub against the pole pieces and exert destructive forces on the guidance system.

Two constants can be derived for a vibrator:

A = The maximum turning moment of the armature guidance system

B = The distance from a defined null point to the armature mounting face.

These constants can be used in the offset load formula

$$F = \frac{A}{B + X}$$

where

X = The distance from the mounting face to the payload centre of gravity

F = A resultant force applied to the guidance system

Offset load calculations should be made whenever the vibrator is to be used in the horizontal axis. For vertical use, value A is used as a limit for the maximum moment which may be applied to the armature assembly.

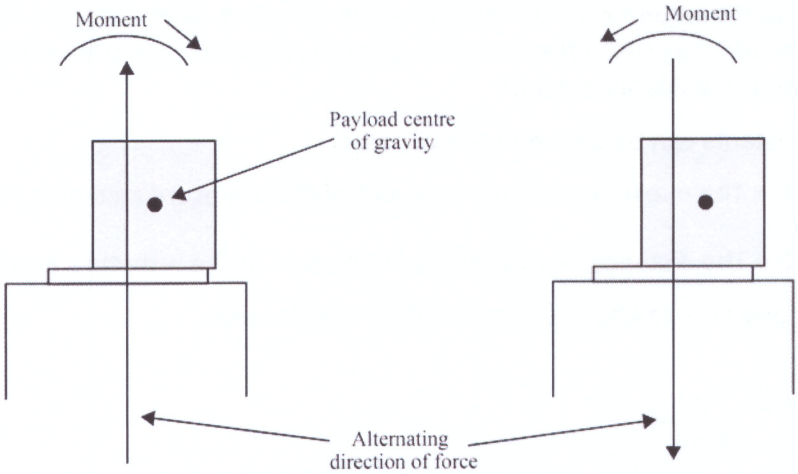
Values of A and B for V450 vibrators are given in Chapter 1 and should be substituted in actual calculations for those used in the following examples.

Note: The vibrator limitations detailed in this section do not take into account the possibility of cross-axial resonances. Resonances can only be determined by effective monitoring of cross-axial acceleration.

2. Vertical operation

Attention to the method of mounting a payload to the vibrator is vital. An unsatisfactory fixture can cause severe cross-axial forces on the vibrator and subject both vibrator and payload to forces beyond which they were designed to be tested.

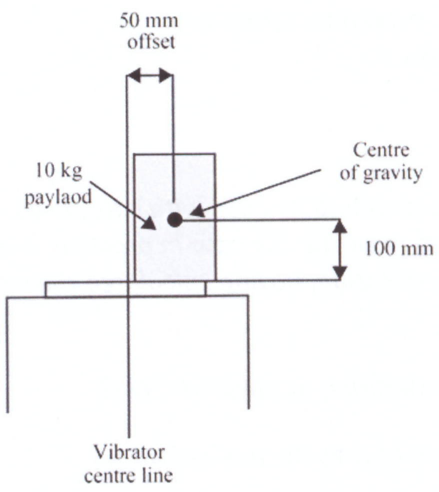
Symmetry of mounting is of prime importance. Every effort must be made to position the payload centre of gravity on the armature axis. If the payload is incorrectly positioned an alternating force of high magnitude can result:



Assume a vibrator for which A = 45 N m, and B = 0.062 m, giving the following offset load formula:

$$F = \frac{45}{0.062 + X}$$

A payload of 10 kg, mounted 50 mm offset from the vibrator centre line, is to be accelerated at 5 g_n. The payload centre of gravity is 100 mm above the load mounting face:



Since force = mass x acceleration the moment applied to the armature can be calculated as follows:

Force	= 10 x 5 x 9.80665
	= 490.3 N
Moment	= 490.3 x 0.05
	= 24.5 N m

This value should always be lower than the maximum turning moment.

In practice, it is wise to calculate the maximum cross-axial acceleration limit as follows, and to monitor this during testing:

Maximum allowable moment A	=	45 N m
Effect of offset load (from previous example)	=	24.5 N m
Maximum allowable moment due to cross-axial acceleration	=	45 – 24.5 N m
	=	20.5 N m

Using the offset load formula $F = \dfrac{A}{B + X}$

Maximum allowable cross-axial force $= \dfrac{20.5}{0.062 + 0{,}1}$

$= 126.5$ N

Therefore, maximum cross-axial acceleration $= \dfrac{126.5}{10}$

$= 12.65\ m/s^2\ (1.29\ g_n)$

Note: This figure should be used with caution as it assumes a perfectly rigid payload and fixture which may not be the case in practice. It is preferable to monitor the armature for cross-axial acceleration, having calculated the maximum allowable acceleration as follows:

Maximum acceleration at payload C of G $= 1.29\ g_n$

Distance from C of G to the null point $= 62 + 100$

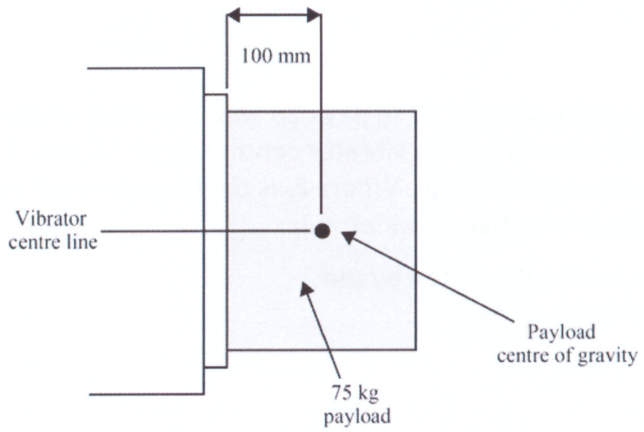
Maximum acceleration at armature face $= \dfrac{1.29 \times 62}{62 + 100}$

$= 0.49\ g_n$

3. Horizontal operation

When a trunnion-mounted vibrator is rotated to the horizontal, the maximum load it can support under static conditions can be calculated from the offset load formula. **This value is also the maximum load the vibrator can support under dynamic conditions, provided that the payload centre of gravity aligns with the centre of the armature.**

Example: It is proposed to attach a payload of 75 kg to the horizontally rotated vibrator. The payload centre of gravity is 100 mm from the armature mounting face. Confirm that the payload will not cause damage to the suspension system, assuming that the payload centre of gravity is on the same axis as the vibrator centre line.



$$F = \frac{A}{B + X}$$

$$= \frac{45}{0.062 + 0.1}$$

$$= 278\ \text{N}$$

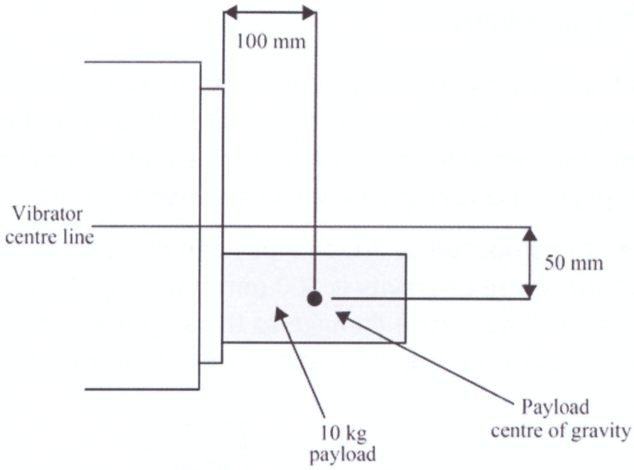
Using mass = force / acceleration,

$$M = \frac{278}{1 \times 9.80665} = 28.3\ \text{kg}$$

Thus the maximum payload the horizontally rotated vibrator can safely support when the centre of gravity is 100 mm from the armature mounting face is 28.3 kg.

It is therefore NOT safe to test with a 75 kg payload.

If the payload is mounted off-centre, an additional load will be generated in the form of an alternating moment:



This example shows a 10 kg payload with its centre of gravity 100 mm from the armature face and offset from the vibrator centre line by 50 mm. The payload is to be tested at an acceleration level of 5 g_n. Where F_P is the force exerted by the payload and using values B and X from the offset load formula:

The moment induced by the overhanging load	= F_P x (B + X)
	= 10 x 9.80665 x (0.062 + 0.1)
	= 15.9 N m
The moment induced by the 50 mm offset	= 10 x 5 x 9.80665 x 0.05
	= 24.5 N m
Therefore the total moment	= 15.9 + 24.5
	= 40.4 N m
Total allowable moment A	= 45 N m
Maximum allowable moment due to cross-axial acceleration	= 45 – 40.4
	= 4.6 N m
This is equivalent to a force of	$\frac{4.6}{0.062 + 0.1}$
	= 28.4 N

Therefore the maximum cross-axial acceleration at the payload centre of gravity is $= \dfrac{28.4}{10}$

$= 2.84\ m/s^2\ (0.29\ g_n)$

Note: This figure should be used with caution as it assumes a perfectly rigid payload and fixture which may not be the case in practice. It is preferable to monitor the armature for cross-axial acceleration, having calculated the maximum allowable acceleration as follows:

Maximum acceleration at payload C of G $= 0.29\ g_n$

Distance from C of G to the null point $= 62 + 100$

Maximum acceleration at armature face $= \dfrac{0.29 \times 62}{62 + 100}$

$= 0.11\ g_n$